ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

**International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering**

*(A High Impact Factor, Monthly, Peer Reviewed Journal)*

*Website: www.ijareeie.com*

**Vol. 7, Issue 6, June 2018**

# IoT Based Smart Environmental Monitoring Using Wireless Sensor Network

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**ABSTRACT**: The recent changes in climate have increased the importance of environmental monitoring making it a topical and highly active research area. The main objective of proposed system is to provide environmental parameters at remote location using internet. The system represents the environmental and ambient parameter monitoring using low-power wireless sensors connected to the Internet, which send their measurements to a central server. The system will be developed using open source hardware platforms and raspberry pi. Raspberry pi is a small computer with most popular features like low-priced, flexible, fully customizable and programmable tiny PC embedded Linux board and abilities of its usage as a wireless sensor node. From the base station this data uploads every two seconds to the cloud (internet) for further analysis. If a drought condition is identified by the monitoring system then an alert message is sent to the user via text message or email.

**KEYWORDS:** IoT, WSN, Raspberry pi, Sensors, Environmental monitoring.

## I.INTRODUCTION

Tracking the environmental parameters variation is essential in order to determine the quality of our environment. The collected data encompass important details for a variety of organizations and agencies. With the results of monitoring, governments can make informed decisions about how the environment will affect the society and how the society is affecting the environment. Wireless sensor networks (WSNs) are becoming a global technology resulting from the development of low cost and low power wireless technology. WSN refers to a combination of distributed sensors for monitor and records the surrounding conditions of the environment and organize the stored data at server's database. WSNs compute environmental conditions like earth quake, rain falls, light intensity, smoke, fire, wind, and so on.

There are a multitude of applications for WSN. The majority of monitoring applications rely on WSNs, motivated by the indisputable advantages they bring: lower costs due to the replacement of cables, variable network topologies, scalability, and lower maintenance. Wireless sensors and sensor networks have been successfully used in the implementation of solutions belonging to various fields, including environmental monitoring, natural disaster prevention, current consumption monitoring in large buildings, monitoring systems for the dosimeter of radiology operators in healthcare applications, location tracking of people, assets or hazardous gases, gear condition surveillance and process control in industrial environments, also road traffic management in smart cities[2].

### A. Wireless Sensor Networks:

While many sensors connect to controllers and processing stations directly (e.g., using local area networks), an increasing number of sensors communicate the collected data wirelessly to a centralized processing station. This is important since many network applications require hundreds or thousands of sensor nodes, often deployed in remote and inaccessible areas. Therefore, a wireless sensor has not only a sensing component, but also on-board processing,

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communication, and storage capabilities. With these enhancements, a sensor node is often not only responsible for data collection, but also for in network analysis, correlation, and fusion of its own sensor data and data from other sensor nodes. When many sensors cooperatively monitor large physical environments, they form a wireless sensor network (WSN). Sensor nodes communicate not only with each other but also with a base station (BS) using their wireless radios, allowing them to disseminate their sensor data to remote processing, visualization, analysis, and storage systems.

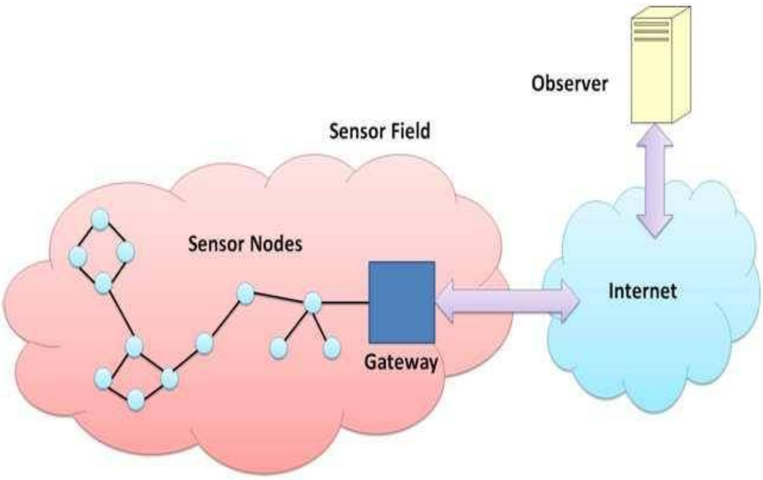


Figure 1: Wireless Sensor Networks.

Minimizing energy consumption and prolonging network lifetime have become primal design goals of next-generation wireless networks, merely due to limited power resources of wireless devices [5].From figure 1. As the wireless Sensor Networks are made up of tiny energy hungry sensor nodes, it is a challenging process to retain the energy level of those nodes for a long period. Wireless Sensor Networks are made up of tiny sensors which are used for monitoring or sensing data. Because of their small size, power supply is provided by a small battery, which, when deployed in a not easily reachable place, cannot be replaced or recharged frequently. Therefore energy efficiency is one of the main constrain in wireless sensor network.

**B. Structure of Sensor Node:**

Sensor nodes, as building blocks of WSN, are consisted of four basic elements shown in Figure 2 the sensor unit, processing unit, communication and power units.

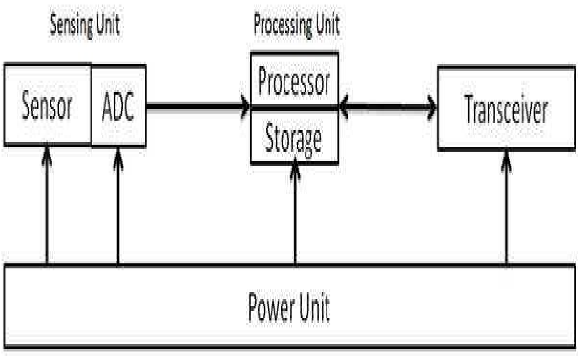


Figure 2: Typical sensor node architecture.

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The hardware of a sensor node generally includes four parts: the power and power management module, a sensor, a microcontroller, and a wireless transceiver. The power module offers the reliable power needed for the system. The sensor is the bond of a WSN node which can obtain the environmental and equipment status. A sensor is in charge of collecting and transforming the signals, such as light, vibration and chemical signals, into electrical signals and then transferring them to the microcontroller. The microcontroller receives the data from the sensor and processes the data accordingly. The Wireless Transceiver (RF module) then transfers the data, so that the physical realization of communication can be achieved. It is important that the design of the all parts of a WSN node consider the WSN node features of tiny size and limited power.

## II. RELATED WORK

Vladimir Vujovi and Mirjana Maksimovic, et.al.[1] this paper propose the Raspberry Pi, cheap, flexible, fully customizable and programmable small computer board and abilities of its usage as WSN node and Sensor Web node. The Raspberry Pi brings the advantages of a PC to the domain of sensor network, what makes it the perfect platform for interfacing with wide variety of external peripherals. It is also conclude that by coupling Raspberry pi with Wi-Fi it can communicate remotely which makes the Raspberry Pi very suitable for the construction of wireless sensor nodes.

George Moise and SilviuFolea, et.al.[2] this paper gives an analysis of major differences and similarities between three different IoT-based wireless sensors for environ-mental and ambient monitoring: one employing User Datagram Protocol (UDP)-based Wi-Fi communication, one communicating through Wi-Fi and Hypertext Transfer Protocol (HTTP), and a third one using Bluetooth Smart. The results shows that Wi-Fi and BLE are two technologies suited for monitoring applications that can successfully compete with the widely used ZigBee protocol.

Sudhir Nikhade, et.al.[3] proposes a wireless sensor network system developed by using open-source hardware platforms, Raspberry Pi and zigbee. This system is suited for a wide variety of applications related to environmental monitoring. For this system uses, Raspberry Pi as a base station, XBee as a networking protocol, and a number of open-source software packages.

LamirShkurti and BesimLimani, et.al.[4] this paper we have developed a system for web based environment monitoring using the WSN Technology. Node MCU controller is used to create sensor node. WSN sensor nodes transmit data to the cloud-based database via Web API request. Node MCU is programmed by using Ardino IDE language. They are created a web application named as WSN Monitoring.

BassemKhalfi and BechirHamdaoui, et.al.[5]this paper focus on Radio Frequency(RF) energy harvesting for multiuser multicarrier mobile wireless networks. Specifically, develop a joint data and energy transfer optimization frameworks for powering mobile wireless devices through RF energy harvesting. Two types of harvesting capabilities are considered at each user one is harvesting only from dedicated RF signals. Another one is hybrid harvesting from both dedicated and ambient RF signals.

Cristian Cocioba and Dan Tudose, et.al.[6] this paper presents an architecture and a software solution for environment monitoring using sensor nodes which can communicate both in Wi-Fi and 802.15.4 networks.

A.Lay-Ekuakille, et.al.[7] This paper presents a procedure for evaluating the in-formative content of an actual network and a new approach of implementing a characterization of hydrological and environmental networks of sensors to be stress-tested. The proposed characterization is implemented by using Ptolemy II tool. It is an open-source simulation and modelling tool intended for experimenting with system design techniques, particularly those that involve combinations of different types of models.

Ana Filipa and OctivianPostolache, et.al.[8] this paper proposes a web information system and a wireless sensor network for indoor or outdoor air quality monitoring. Two different architectures of smart coordinator based on a Raspberry Pi, with and without an Ethernet border router from Jenni embedded computer and wireless network coordinator, were implemented.

Taewoon Kim and J. Morris Chang, et.al.[9]considering the power saving mechanism for 802.11 on large-scale sensor networks. This paper proposes a method that selectively and dynamically changes the membership of nodes and rearranges their traffic to maximize overall sleeping intervals without causing delay to data delivery. To reduce the power consumption of battery-operated sensor devices, they proposed a novel way of utilizing unused AIDs and scheduling traffic delivery so as to reduce the number of unnecessary wake-ups.

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Hsueh-Chun Linis, et.al.[10] This paper is aimed to establish a wireless sensor network (WSN) gateway model prior to the back-end server for diverse environmental monitoring applications. The design cat logs different sensor data with transmission load balance to incorporate heterogeneity of sensor signals, stability of data transportation, and expenditure of mobile communication. As considering a variety of sensor characteristics for environmental monitoring, the proposed WSN gateway is designed with three bridged functions, including serial listener, transaction logger and Internet listener, to enable analog and digital signal conversion, physical data classification, threshold determination, database redundancy and mobile communication.

Akshay D. Deshmukh,et.al.[11]This paper intends to provide information using wireless sensor technology which comprises of raspberry pi, Arduino Nano, Zigbee, wire-less sensor network(WSN) and sensors. Realization of data gathered by sensors based on raspbian linux is displayed on Graphical User Interface (GUI). The sensors will gather the data of various environmental parameters and provide it to raspberry pi which act as a base station. Some sensors will directly process the data and provide it to the raspberry pi while some sensors will provide the data through Arduino Nano to raspberry pi using serial interface.

Sk Riyazhussain, et.al.[12]This paper explains a Raspberry Pi controlled Traffic Density monitoring system. Raspberry pi is used for traffic surveillance purpose where the traffic is continuously monitored and recorded. In addition to this, it is used for detecting the traffic density and gives the traffic report to the travellers. This traffic report is updated periodically and displayed on the screens installed at the public places. These screens can also be used for advertising purposes which is an additional advantage. Using Raspberry Pi one can manage the preference of advertising and displaying traffic report. This installation supports Government by making things digitalized.

Shailendra Singh, et.al.[13] This paper propose an innovative implementation of software aspects of WSN (Wireless Sensor Networking) for monitoring greenhouses in Indian economical condition. Yuktix IOT hardware platform along with end sensor nodes and CDAU (Central data acquisition unit) together can be used to locally or remotely monitor internal conditions of greenhouse chambers using Yuktix cloud via Web-application and Android application as well as their internal environment can be con-trolled locally/remotely using Yuktix controller.

Xuan-Thuan Nguyen, et.al.[14] In this paper , the reliability issue is concentrated on to deliver sustained data over WMSNs for long periods of time, by contrast with the environmental noises. This reliable transport protocol (RTP) combines a modified automatic repeat request error-control with an error-correction mechanism. The experimental results in a Raspberry Pi compute module and an Atmel transceiver prove that RTP can transfer data successfully with a wide range of transmission rates, from 16.6 to 430.5 Kbps, at a distance up to128 m.

**A. Problem Statement**

Develop an environmental monitoring system such that it will help the user to get information about maximum environmental parameters.

**B. Objectives**

1. Remote sensing of environmental parameters like light intensity, rain-fall, earthquake, CO2, fire.
2. Development of energy harvesting algorithm at sensor node to minimize the energy consumption at sensor node.
3. Priority base scheduling for sending any critical or emergency message.
4. Use of raspberry pi as a wireless sensor node.

## III. SYSTEM ARCHITECTURE

Wireless senor network system requires development and integration of many hardware and software components. Figure 3 shows the overall system architecture of environmental monitoring WSN system. This system consists of raspberry pi as a sensor node controller [1].Each sensor node is combination of sensors, raspberry pi and Wi-Fi (based on IEEE 802.11) which is inbuilt in raspberry pi. Sensor node is primarily responsible for information or sensor data collection and distribution.

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In this system architecture, we have attached the gateway node of wireless sensor network in one single-board computer (raspberry pi) hardware platform, which helps to reduce the cost and complexity of deployment.

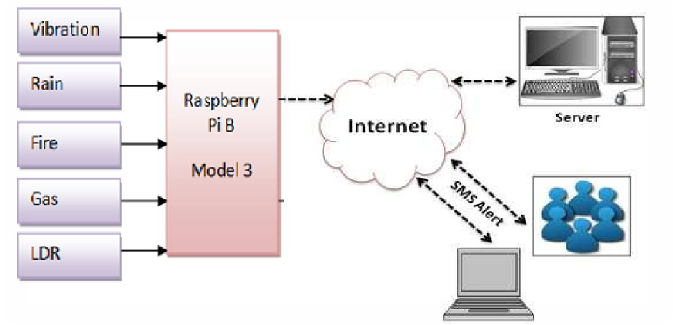


Figure 3: Overall System Architecture.

**A. Raspberry Pi**

The raspberry pi is a low cost, low power credit card size single board computer which has recently become very popular [1]. The raspberry pi is the cheapest ARM11 powered Linux operating system capable single board computer board. This board runs an ARM11 microcontroller @700MHz and comes with a 1GB of RAM memory. In this paper, raspberry pi3 model B is used as shown in figure 3, as this model has better specifications as compared to other raspberry pi models. It supports a number of operating systems including a Raspbian which is recommended by raspberry pi foundation, which is used in our design. Raspberry Pi can be connected to the internet through Wi-Fi which is inbuilt in raspberry pi 3. It also comes with 4 USB ports and one Ethernet port. The raspberry pi is booted by external SD or micro SD card [15].

The Raspberry Pi 3 Model B is the latest version of the Raspberry Pi, a tiny credit card size computer. Just add a keyboard, mouse, display, power supply, micro SD card with installed Linux Distribution and you'll have a fully fledged computer that can run applications from word processors and spreadsheets to games [15].

The Raspberry Pi 3 Model B is the latest version of the $35 Raspberry Pi computer. The Pi isn't like your typical machine, in its cheapest form it doesn't have a case, and is simply a credit-card sized electronic board of the type you might find inside a PC or laptop but much smaller[15].

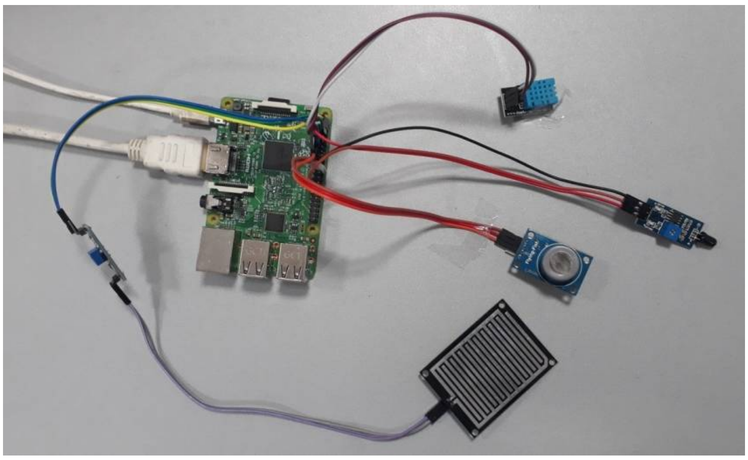

Figure 4.Raspberry pi with sensor

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**B. Sensing Nodes**

A sensor is a device which is capable of converting any physical quantity to be measured into a signal which can be read, displayed, stored or used to control some other quantity. This signal produced by the sensor is equivalent to the quantity to be measured. Sensors are used to measure a particular characteristic of any object or device [16].

**a) Flame Sensor**

This module is sensitive to the flame and radiation. It also can detect ordinary light source in the range of a wavelength 760 nm-1100 nm. The detection distance is up to 100 cm. The Flame sensor can output digital or analog signal. It can be used as a flame alarm or in firefighting robots. [16].

**b) MQ 7 Sensor**

This is a simple-to-use Carbon Monoxide (CO) sensor, suitable for sensing CO concentrations in the air. The MQ-7 can detect CO-gas concentrations anywhere from 20 to 2000ppm. This sensor has a high sensitivity and fast response time. The sensor's output is an analog resistance. The drive circuit is very simple; all you need to do is power the heater coil with 5V, add a load resistance, and connect the output to an ADC [16].

**c) Rain Sensor**

The rain sensor module is an easy tool for rain detection. It can be used as a switch when raindrop falls through the raining board and also for measuring rainfall intensity. The module features, a rain board and the control board that is separate for more convenience, power indicator LED and an adjustable sensitivity though a potentiometer. The analog output is used in detection of drops in the amount of rainfall. Connected to 5V power supply, the LED will turn on when induction board has no rain drop, and DO output is high. When dropping a little amount water, DO output is low, the switch indicator will turn on. Brush off the water droplets, and when restored to the initial state, outputs high level. [16].

**d) Digital Vibration Sensor**

Vibration sensor is used originally as vibration switch because of its high sensitivity; it is sensitive to environment vibration, and generally used to detect the ambient vibration strength. When module did not reach the threshold in shock or vibration strength, DO port output gets high level and when external vibration strength exceeds the threshold, D0 port output gets low level. Small digital output D0 can be directly connected to the microcontroller, for the microcontroller to detect low level, thereby to detect the ambient vibration. Small digital output DO can directly drive the relay module, which can be composed of a vibration switch. When this no vibration, this module output logic LOW the signal indicate LED light, and vice versa. [16].

**C. Web Application**

The system architecture is presented in Figure 3. The network sends all the measurements to the sink node which is connected to the Laptop via a Wi-Fi. The PC has a simple Java program which parses packets from the serial port and stores them to a MySQL database. The program has no control functions, it only stores incoming packets. The database contains information about the actual measurements. In addition to physical quantities also link qualities and statistics of successfully delivered messages are stored in the database. The database has also basic information about nodes, locations etc. Raw packet data is also stored to the database. The PC relies on freeware: the operating system is Ubuntu Linux, Tomcat/Glassfish is used as the HTTP server, and the web application is built with the help of the open-source Apache Struts framework. The application enables browsing of stored measurements and communication statistics. The measurement period can be defined by start and end dates or it can be chosen from pre-entered values for the last day, week, or month. In addition to physical quantities also statistical information about measurements can be monitored in the web site.

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## IV. FLOW OF SYSTEM

Following figure shows the Flow of the system,

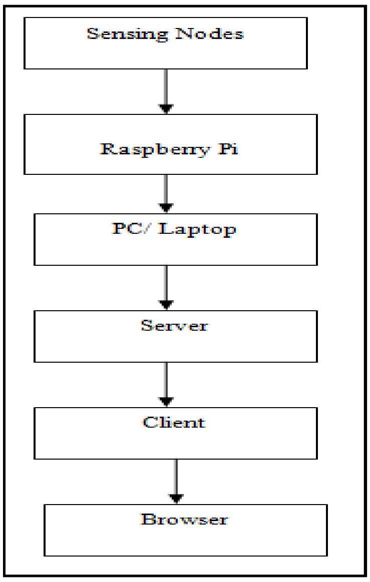

Figure 5 : Flowchart

**Algorithm:**

1) Start
2) Sensing node sense the physical measurement
3) If sensing node change status , sensing node send status to Raspberry pi
4) Raspberry pi send data to PC/Laptop
5) Reading stored in MySQL database
6) Server send sensor status to client
7) Client side browser display current status of Environment
8) Perform from step 2 again
9) Stop

## V. RESULT AND DISCUSSION

The amount of collected data in the Environment monitoring system project was large. A total of 1000 received packets were stored in the database. Based on this material, the researchers were able to analyse both the physical circumstances of the environment monitoring system and the reliability of the network.

### A. Environmental Monitoring

The WSN in the Environmental monitoring system collected sensors values for one week. Typically, Fire, Gas Leakage, Vibration, Rain falls, Light intensity measurements were done manually a few times in day. The WSN reduced the need for manual measuring and recording in the database and made constant real-time data. Moreover, the network increased the number of measurements manyfold and, therefore, the network gave more information about the physical circumstances of the environment. The measurements were stored in an SQL database, and are thus easily available for further studies.

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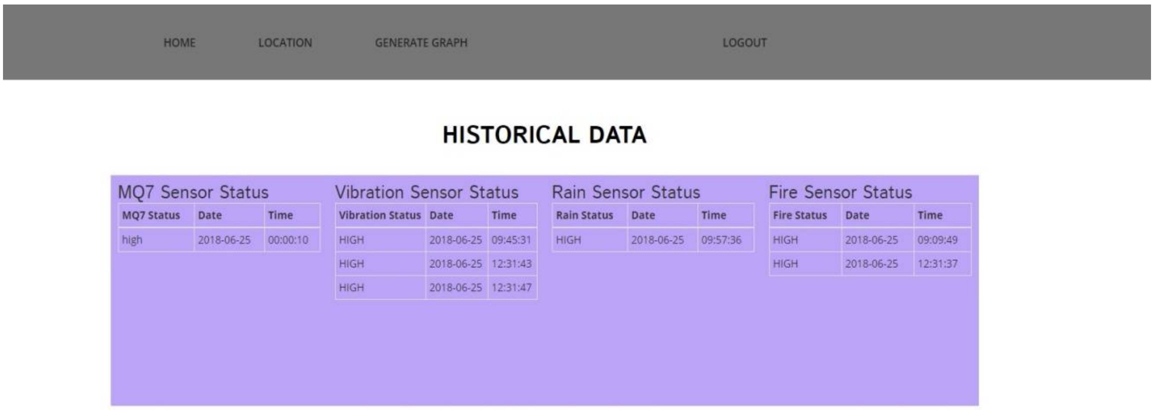


Figure 6: Output on browser

### B. Reliability of communication

Reliability of IEEE 802.11 based wireless communication was one of research subjects in this project. The plan was to relate it to the number of packet losses. Due to collisions and external disturbance packet losses are possible. The throughput of the rear cluster was very good and the front cluster was almost 100%. The period was free from device failures and the throughput of the routing nodes was 100%, and thus the results of the ratio of received packets to delivered packets at the cluster heads. It can be concluded that wireless links were very reliable. Statistical calculation was based on 1000 received packets.

## VI. CONCLUSION

The presented design can be used to remotely monitor weather parameters like daylight, rainfall, fire and gas leakage etc. The data can be stored online, which can be used to forecast weather and eventually analyze climate patterns, as well as for other meteorological purposes. All aspects of the WSN Platform are considered and discussed. WSN technology that will convert the way we compute, understand and manage the natural environment. For the first time, data of different types and places can be merged together and accessed from anywhere. Some significant progress has been made over the last few years in order to bridge the gap between theoretical developments and real deployments, but in proposed system all that mistakes and defect in existing system have removed.

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